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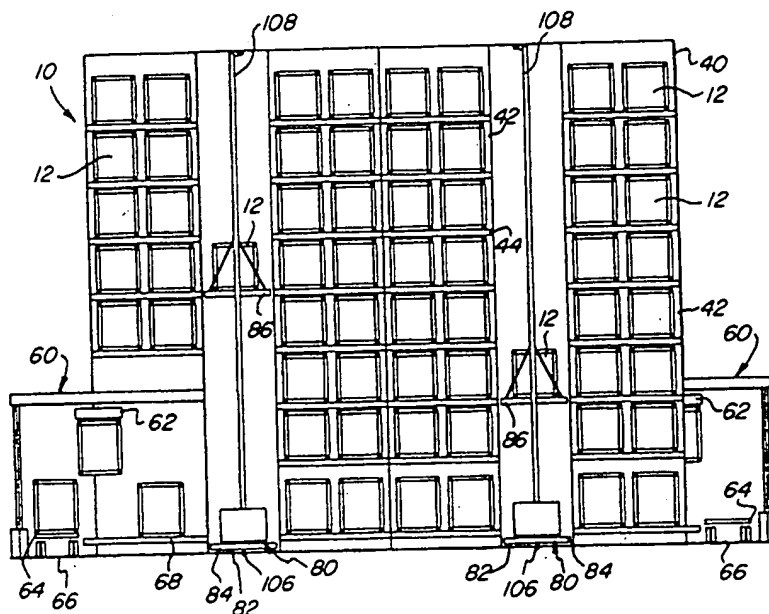
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(57) Abstract

An apparatus and method for handling and storing marine containers (12) transports containers (12) using a shuttle (88) that is movable sideways from an elevating support frame (86) in an elevating transfer vehicle (80). The shuttle (88) can lift a container and travel into a bay of a large storage rack (40). The shuttle can move the containers within the storage rack (40), or to a portal (60) where it can be temporarily stored or picked up immediately by a ground vehicle.

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MARINE CARGO CONTAINER HANDLING AND STORAGE

BACKGROUND OF THE INVENTIONField of the Invention

This invention relates to a system for handling and storage of marine cargo containers providing high throughput rates, and permitting quick retrieval of stored containers for delivery to a marine vessel or a land carrier, thereby minimizing delays and unnecessary use of dock and cargo loading space associated with prior art methods of storing and handling marine containers.

Discussion of the Prior Art

Marine containers for shipment of cargo are generally rectangular structural containers that are provided with ISO fittings at each of their upper and lower corners. Marine containers are of various lengths, typically 20, 24, 30, 40, or 45 feet. These different lengths of containers are normalized when evaluating marine cargo container storage to a twenty foot equivalent unit ("TEU"). The conventional methods and equipment for handling and storage of marine containers use overhead cranes having a spreader with hooks, which hooks fit into and engage openings in the ISO fittings at the upper corners of the container. Thus, for example, in handling inbound marine containers, a dock crane will lift such containers from the deck or hold of a marine vessel and deliver them to a truck. The truck will then transport the container to a storage area, where it is carried by a transtainer (a rail guided or rubber tired overhead straddle crane), and stacked on top of other such containers. Containers stacks commonly contain as many as six such containers, all stacked one on top of

the other. Such stacking is possible because the containers are structural elements, and they are typically stacked such that the ISO fittings of an upper container are seated on and supported by the ISO fittings of the container beneath it.

The stored container will then be retrieved from storage when the overland carrier, such as a truck or railway car, arrives and is ready to receive the container. The retrieved container is re-hooked to the transtainer, and then lifted and carried by the transtainer to a truck loading site, where it is then mounted to a truck bed.

It is to be appreciated that in order to retrieve a selected container, that it may be necessary to move some five other containers in order to obtain access to the desired container, i.e., when the desired container is at the bottom of a stack of six containers. This shuffling of containers is time inefficient and creates additional problems in tracking the location of the containers that were moved; alternatively, it is then necessary to replace the five containers into their original stack location so that they remain in their original assigned location.

The same procedures will generally apply when containers are moving in the reverse direction, i.e., when containers are being delivered to a marine terminal by ground transportation, for storage and subsequent loading on a marine vessel for overseas transport. Thus the container will be picked up from the bed of the truck, stored in the storage area, and then retrieved for loading to a marine vessel.

It has been proposed to automate the storage of marine containers as in U.S. Patent No. 5,540,532. The present application represents an improvement upon the referenced patent.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide a system and method for the handling of marine cargo containers that permits automated handling and storage of such marine containers. It is an object of the invention to provide such a system and method that permits near random access to stored containers for prompt retrieval.

It is an object of the invention to provide such a system and method to substantially increase the speed of retrieval and handling, to permit quicker loading and unloading, of marine cargo containers to be located in storage. It is an object of the invention to substantially reduce labor costs associated with handling of marine cargo containers.

It is an object of the invention to provide such a system and method to substantially increase the speed of retrieval and handling, to permit quicker loading and unloading, of marine cargo containers at ground transport loading areas, thus permitting shorter periods for loading or unloading of such containers, and thereby increasing the number of ground transport vehicles that can be loaded or unloaded during a given time period.

Other objects, aspects and features of the present invention in addition to those mentioned above will be pointed out in or will be understood from the following

detailed description provided in conjunction with the accompanying drawings.

SUMMARY OF THE INVENTION

5 The objects of the invention are achieved by a system for marine cargo container handling and storage including two principal subsystems, namely, a storage rack having an overhead portal shuttle system, and an elevating transfer vehicle subsystem for moving a container within the storage rack.

10 The storage rack comprises a plurality of vertically and horizontally located bays. Each bay is provided with supporting brackets for supporting the container at its ISO fittings at the four lower corners of the container, preferably by providing a shallow cup or nest for
15 receiving the ISO fittings. The cups are preferably the same shape as the ISO fittings, i.e., square, and are provided with vertical or sloped sidewalls to retain the ISO fitting in the bracket, to prevent the container from sliding off the supporting bracket under, for example,
20 forces arising from winds.

The bays in the storage rack are preferably oriented to receive the containers longitudinally, i.e. sideways in the bay. The bays preferably have a depth sufficient to store two containers, i.e., there are two container
25 positions in each bay.

The portal crane system has an overhead lifting shuttle crane for lifting or depositing the container from or to a vehicle, such as the automated transport system or a truck, located in a loading/unloading zone.
30 The overhead portal shuttle conveys the container between

the loading/unloading zone and a portal buffer area. The portal buffer area provides a temporary storage location of containers as they are being stored to or removed from the storage rack, pending availability of the elevating transfer vehicle needed to move the container to its storage destination.

An elevating transfer vehicle, described in greater detail below, has access to and is movable to extend laterally into the portal buffer area to remove or place a container in the portal buffer area, respectively for delivery to a storage bay in the storage rack, or for pickup by the portal overhead crane and delivery to a truck or other ground transport.

The elevating transfer vehicle comprises a movable carriage having a cradle which can be lifted or lowered as desired, and a shuttle that can be moved laterally in and out of the cradle to extend into a bay in the storage rack. The shuttle is equipped to receive a container, and in particular has a pneumatic lifting pad or mattress that can be inflated to lift the container, or deflated to lower the container. The lifting pad can lift the container above the supporting brackets of the storage rack so that the container can be placed in, and removed from, a storage bay without interference with the storage rack by the lateral movement of the shuttle. The shuttle can also load and unload a container at the storage rack portal by the same handling method.

The movable shuttle in the cradle comprises a framework, a plurality of wheels located adjacent ends of the framework, and an electric motor operably connected to the wheels to drive the wheels to move the shuttle to

extend laterally from the cradle. Preferably, the cradle and storage rack are provided with rails along lateral sides of each bay for receiving and supporting the shuttle wheels.

5 In some situations, where a container is being transferred to or from a dockyard automatic guided vehicle ("AGV"), the shuttle may transfer the container directly to or from the AGV without the intermediate step of depositing the container at the portal buffer area for
10 transfer to the overhead lifting shuttle.

 Preferably, a system for wireless communication and control of the elevating transfer vehicle is also provided. A container tracking system is also preferably provided, and comprises digital recording apparatus for
15 recording position information received from the position information transmitting means and for recording information identifying a container located at a position identified by the position information, and means for retrieving recorded container identifying and position
20 information.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention may be more clearly understood from the following description of a specific and preferred embodiment read in conjunction with the accompanying schematic and detailed drawings; wherein:

FIG. 1 is a cross-sectional schematic view showing an embodiment of an elevating transfer vehicle and storage rack of the apparatus of the invention.

FIG. 2 is a perspective breakaway view of an embodiment of an elevating transfer vehicle and a storage rack of the apparatus of the invention.

FIG. 3 is a side elevation view of an embodiment of an elevating transfer vehicle of the apparatus of the invention.

FIG. 4 is an end elevation view of the elevating transfer vehicle of FIG. 3.

FIG. 5 is a top plan view of the elevating transfer vehicle of FIG. 3.

FIG. 6 is a detail side elevation view of the shuttle located in the cradle of the elevating transfer vehicle of FIG. 3.

FIG. 7 is an end elevation view of the shuttle of FIG. 6.

FIGS. 8 and 9 are detail cross-sectional views of a shuttle of FIG. 6 as it performs the step of lifting a container to remove it from a storage rack.

FIG. 10 is a top plan view of an embodiment of the storage rack and apparatus in accordance with the invention shown schematically in FIG. 1.

5 FIG. 11 is a top plan view of an alternate embodiment of a storage rack and apparatus in accordance with the invention.

FIG. 12 is a cross-sectional schematic view of the storage rack and apparatus of FIG. 11.

10 FIG. 13 is a top plan view of an overhead portal shuttle system in accordance with the invention.

FIG. 14 is a side elevation view of the overhead portal system of FIG. 13.

15 FIG. 15 is a side cross-sectional view of a supporting bracket in a storage rack in a sloped side wall embodiment.

FIG. 16 is a top plan view of the bracket of FIG. 15.

20 FIG. 17 is a side cross-sectional view of a supporting bracket in a storage rack in a vertical side wall embodiment.

FIG. 18 is a top plan view of the bracket of FIG. 17.

FIG. 19 is a side cross-sectional view of an alternate lifting device.

FIG. 20 shows another view of the alternate lifting device of FIG. 19.

It should be understood that the drawings are not necessarily to exact scale and that certain aspects of the embodiments, may be emphasized for clarity of the invention. Actual embodiments, or installations thereof may differ, depending upon the particular location or application for which the marine cargo handling and storage system is designed.

10

DETAILED DESCRIPTION OF DRAWINGS

15

Referring to FIGS. 1-18, and wherein like numbers in different drawing figures refer to the same elements, a system 10 for marine cargo container handling and storage includes a storage rack 40 having a storage rack portal 60; and an elevating transfer vehicle 80 for moving a container 12 within the storage rack 40.

20

Referring now to FIGS. 1, 2, 8, 9, 10 and 11, the storage rack 40 comprises a plurality of vertically and horizontally located bays 42 formed by metal beams 44. Each bay 42 is provided with supporting brackets 46 for supporting container 12. Container 12 is a conventional marine container, and may be of any length. Container 12 has four lower corners 14, each provided with conventional square ISO fittings 16.

25

30

As shown in FIGS. 15-18, the supporting brackets 46 are square in shape to receive the bases of the square ISO fittings 16. The brackets form a square shaped cup 47 into which the ISO fittings 16 are received. The square shaped cup 47 has side walls 48 which may be either generally vertical walls 49, or sloped walls 50 that are

angled from a flat floor 51 in the center of the square shape cup upwardly. The side walls 48 serve to prevent the container from shifting off of the brackets 46 under lateral forces caused, for example, by wind. In this respect, the vertical sidewall 49 embodiment provides a higher degree of security in case of such lateral forces. The sloped side wall 50 provides less security, but has the advantage of providing a self-centering effect when the container is being placed on the brackets 46, as the weight of the container will tend to cause it to settle with the base of the ISO fittings 16 centered in the flat floor areas 51 of the brackets 46.

The bays 42 in the storage rack 40 are preferably oriented to receive the containers 12 longitudinally, i.e. sideways in bays 42. The bays 42 preferably have a depth sufficient to store two containers 12, thus, there are two container positions with the necessary supporting brackets 46 at each position in each bay 42. The storage rack 40 preferably is a vertical stack of from six to twelve bays 42. The number of bays 42 in a horizontal direction is determined as necessary to store the expected container traffic.

Preferably, there are two such storage racks on either side of a lane 82 traversed by elevating transfer vehicle 80. As can be seen in FIGS. 1, 10, 11 and 12, multiple sets of opposing storage racks 40 facing each other across a lane 82 may be located together in rows.

Containers are loaded to the storage rack 40 through a storage rack portal 60. There may be one or more such portals 60 for each length of storage rack 40. As can be seen in FIGS. 1 and 10, portals 60 may be located for

interfacing with trucks or AGVs arriving at the outer walls of storage rack 40. Alternatively, as shown in FIGS. 11-12, a portal 160 may be situated with trucks or AGVs passing below the storage rack 40. Portal 60 thus provides a side-to-side overhead portal shuttle, while the overhead portal shuttle of portal 160 provides a more substantial vertical component as well. Portals 60, 160 are preferably located in a central part of each length of their storage racks and each has an overhead portal shuttle 62, 162 for lifting or depositing a container 12 from or to a vehicle 64, such as a truck or AGV, located in their respective loading/unloading zones 66, 166. The overhead portal shuttles 62, 162 convey a container 12 between their respective loading/unloading zones 66, 166 and their respective portal buffer areas 68, 168. The portal buffer areas 68, 168 provide a temporary storage location for containers 12 as they are being stored to or removed from the storage rack, pending availability of the equipment needed to move the container 12 to its immediate destination.

Referring to FIGS. 13-14, an overhead portal shuttle 260 is shown in detail. Portal shuttle 260 includes a rail guided carriage 262 supporting a hoist frame 266 which holds a spreader 264. Spreader 264 has twist lock fittings 267 that engage ISO fittings 15 at the four upper corners of container 12. Spreader 264 is supported by cables and a winch provided on hoist frame 266 for lifting the spreader 264. Portal shuttle 260 is movable between positions above the portal buffer area 268 and the loading/unloading zone 269.

Portal shuttle 260 has positioning adjusting means to accommodate the possibility that a truck located in

the loading/unloading zone 266 will not be located precisely in position and parallel to the portal shuttle 260. These positioning adjusting means include a motor driven lead screw 270 and corresponding pivot 272
5 permitting angular correction of the hoist frame 266 relative to the position of a truck. Preferably, hoist frame 266 can be adjusted plus or minus three degrees from dead center. Another positioning adjusting means includes a motor driven lead screw 274 permitting forward
10 and backward positioning of the hoist frame 266. These two positioning means provide substantial ability to accommodate parking errors by a truck of AGV.

An elevating transfer vehicle 80, described in greater detail below, has access to and is movable to
15 extend laterally into the portal buffer areas 68 and 168 to remove a container 12 in the portal buffer areas 68, 168 for delivery to a storage bay 42 in the storage rack 40. Elevating transfer vehicle 80 will also operate to deliver a container 12 to portal buffer areas 68, 168
20 from a bay 42, for pickup by the portal overhead crane 62 and delivery to a truck or other ground transport vehicle.

The elevating transfer vehicle 80 comprises a movable carriage 84 having a cradle 86 which can be
25 lifted or lowered as desired, and a shuttle 88 that can be moved laterally in and out of the cradle 86 to extend into a bay 42 in the storage rack 40.

The shuttle 88 is equipped to receive a container 12, and in particular has a pneumatic lifting pad or
30 cushion 90, which, as shown in FIG. 9, lifts the container by its base without requiring engagement with

the ISO fittings. The lifting pad 90 lifts the container 12 above the supporting brackets 46 of the storage rack 40 and the container 12 can therefore be placed in, and removed from, a storage bay 42, without interference with the storage rack 40, by the lateral movement of the shuttle 88. The shuttle 88 can also load and unload a container 12 at the storage rack portal 60. There may be one large lifting pad 90 or a number of separately inflatable lifting pads 90. In either event it is desirable to maximize the surface area of the lifting pads so that load in the container does not cause warping of the container.

Lifting pad 90 is constructed of a durable coated fabric material designed to carry significant loads and to endure severe conditions including possible snagging, ripping etc. from contact with the container 12. The pad is inflated with air using a suitable air compressor system.

Alternate lifting devices, as shown in FIGS. 19-20, may include devices such as those that engage the ISO fittings at the lower corners of the container 12. Such alternate lifting devices may comprise pneumatic or hydraulic cylinders, screw actuators, or other heavy duty lifting equipment. Such alternate lifting devices lift the container 12 above the supporting brackets 46 of the storage rack 40 and the container 12 can therefore be placed in, and removed from, a storage bay 42, without interference with the storage rack 40, by the lateral movement of the shuttle 88. Preferably, the alternate lifting devices are provided with upwardly extending pins for locating in an inner portion of the bottom apertures of the ISO fittings 16. In such case, at least some of

the supporting brackets 46 are provided with upwardly extending pins for locating in an outer portion of the bottom apertures of the ISO fittings, i.e., the supporting brackets and alternate lifting devices can
5 both simultaneously be received in the ISO fitting.

The movable shuttle 88 in the cradle 86 comprises a framework 95, a plurality of wheels 96 located adjacent ends of the framework 95, and at least one electric motor 98 operably connected by a drive shaft and gear train to
10 the wheels 96 to drive the wheels 96 to move the shuttle 88 to extend laterally from the cradle 86. Preferably, the storage rack 40 is provided with rails 100 along lateral sides of each bay 42 for receiving and supporting the shuttle wheels 96. Cradle 86 similarly has rails 101
15 for supporting shuttle wheels 96.

The carriage 84 of the elevating transfer vehicle has at least one carriage wheel 102 at each end of the carriage and an electrical motor 104 coupled to the carriage wheels 102 for driving the carriage wheels 102
20 to move the elevating transfer vehicle 80 along lane 82. Lane 82 is preferably a rail 106 and wheels 102 rest on and are guided by rail 106 to insure the consistent position of the elevating transfer vehicle relative to the position of the storage rack 40.

At least one vertically extending mast 108 extends from the carriage 84 to a height sufficient to permit access to a highest bay 42 in the storage rack 40. The cradle 86 is movably mounted to the mast 108 by a pulley and wire cable apparatus 110. An electric motor 112 is
25 operably connected to the pulley and cable apparatus 110
30

to move the cradle 86 upwardly and downwardly along the mast 108.

5 The shuttle 88 can move freely anywhere within its assigned area. Since the containers 12 may be stored double deep in bays 42, the shuttle will be used to occasionally move a front container to another location before removing a rear container in a bay 42. The shuttle will have an average response time to retrieve a container in a bay which substantially improves over
10 conventional systems.

Preferably, a system for wireless communication and control of the elevating transfer vehicle 80 is provided, which system may include vertical and horizontal position encoders 111 located on the elevating transfer vehicle 80
15 for determining the position of the cradle 86 and encoding vertical and horizontal position information; means for transmitting encoded vertical and horizontal position information from the elevating transfer vehicle 80 to a control unit; means for positioning the elevating
20 transfer unit 80 and the cradle 86 responsive to vertical and horizontal position inputs; and means for transmitting vertical and horizontal position inputs from the control unit to the positioning means. This system permits remote operation of the shuttle to retrieve
25 containers 12 stored in rack 40.

Preferably, a container tracking system is also provided, and comprises digital recording apparatus for recording position information received from the position information transmitting means and for recording
30 information identifying a container 12 located at a position identified by the position information, and

means for retrieving recorded container identifying and position information. Such a system will keep track of each container if it is moved into different bays 42 in the storage rack 40 when needed to obtain access to a rear container in a bay.

An automated self-propelled vehicle 122, that can be controlled by various methods, including, an on-board computer, remote control by infrared communication with a control unit, or other automated guidance systems as are known in the art can be used in conjunction with the invention.

As those skilled in the art will recognize, however, the invention is not necessarily limited thereto and the inventive concept may be implemented in other embodiments.

As is apparent from the above description, the present invention provides unique advantages in the handling and storage of marine containers, providing the first integrated system for efficiently transporting, locating, and retrieving such containers. The invention provides a high density marine container storage system that is particularly useful in crowded ports where, in order to expand container traffic, additional port space is required. The invention permits an expansion of port traffic without acquisition of costly real estate.

CLAIMS

1. A system for marine cargo container handling and storage, comprising:

5 a storage rack having a storage rack portal and a plurality of vertically and horizontally located bays for receiving marine cargo containers, each said bay being provided with supporting brackets for supporting the container by ISO fittings at four lower corners of the container, said brackets having a floor for receiving a base of said ISO fittings and having sidewalls for preventing lateral shifting of said ISO fittings;
10 and

an elevating transfer vehicle having

means for moving said elevating transfer vehicle adjacent to said storage rack,

15 a cradle,

means for lifting said cradle provided in said elevating transfer vehicle, and

a shuttle receivable in said cradle and being movable to extend laterally from said cradle to extend into a bay of said storage rack, and being provided with a pneumatic lifting device for lifting the container above said supporting brackets, said lifting of the container by said pneumatic lifting device and lateral movement of said shuttle between
20 said cradle and said bay permitting transfer of the container from said cradle into said bay and removal of the container from said bay to said cradle, and further permitting loading and unloading of the container to and from said shuttle at said storage
25 rack portal.
30

2. A system in accordance with claim 1, wherein said supporting brackets are provided with vertical sidewalls.

3. A system in accordance with claim 1, wherein said supporting brackets are provided with sloped sidewalls.

4. A system in accordance with claim 1, wherein said pneumatic lifting device comprises an inflatable air pad positioned to lift said container by supporting a floor of said container inwardly of said four ISO fittings at said four lower corners of said container.

5. A system in accordance with claim 1, wherein said movable shuttle in said cradle comprises: a framework, a plurality of wheels located adjacent ends of said framework, and an electric motor operably connected to a said wheel to drive said wheel to move said shuttle to extend laterally from said cradle.

6. A system in accordance with claim 5 wherein said storage rack and said cradle are provided with rails for receiving and supporting said shuttle wheels, said storage rack rails being located along lateral sides of each said bay below said supporting brackets.

7. A system in accordance with claim 1, wherein said elevating transfer vehicle further comprises: a carriage; at least one carriage wheel at each end of said carriage; an electrical motor coupled to at least one said carriage wheel for driving said carriage wheel to move said elevating transfer vehicle; at least one

vertically extending mast extending upwardly from said carriage to a height sufficient to permit access to a highest bay in said storage rack; an electric motor for operation of a pulley and chain apparatus to move said cradle upwardly and downwardly along said mast; and vertical and horizontal position encoders for determining the position of said cradle and encoding vertical and horizontal position information regarding the position of said cradle.

8. A system in accordance with claim 7, further comprising means for wireless communication and control of said elevating transfer vehicle having:

means for transmitting encoded vertical and horizontal position information from said elevating transfer vehicle to a control unit;

means for positioning said elevating transfer unit and said cradle responsive to vertical and horizontal position inputs; and

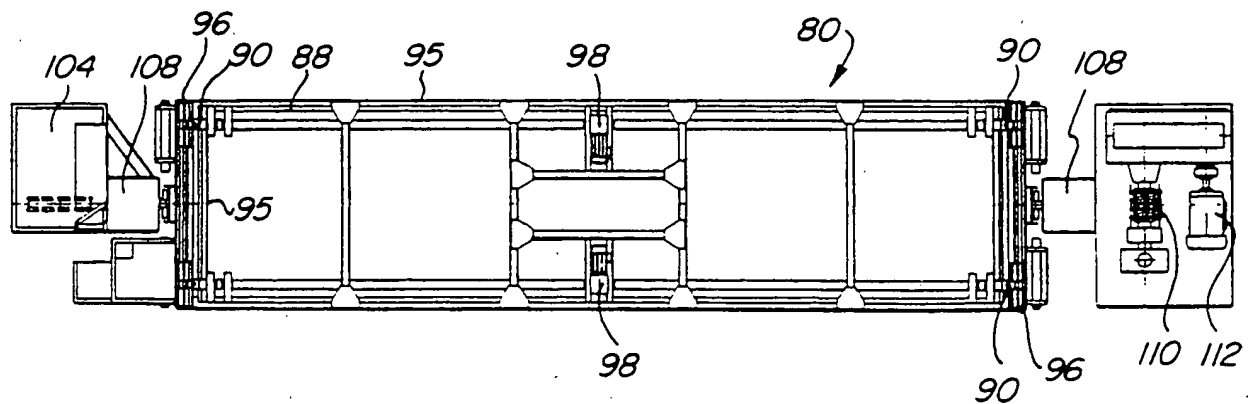
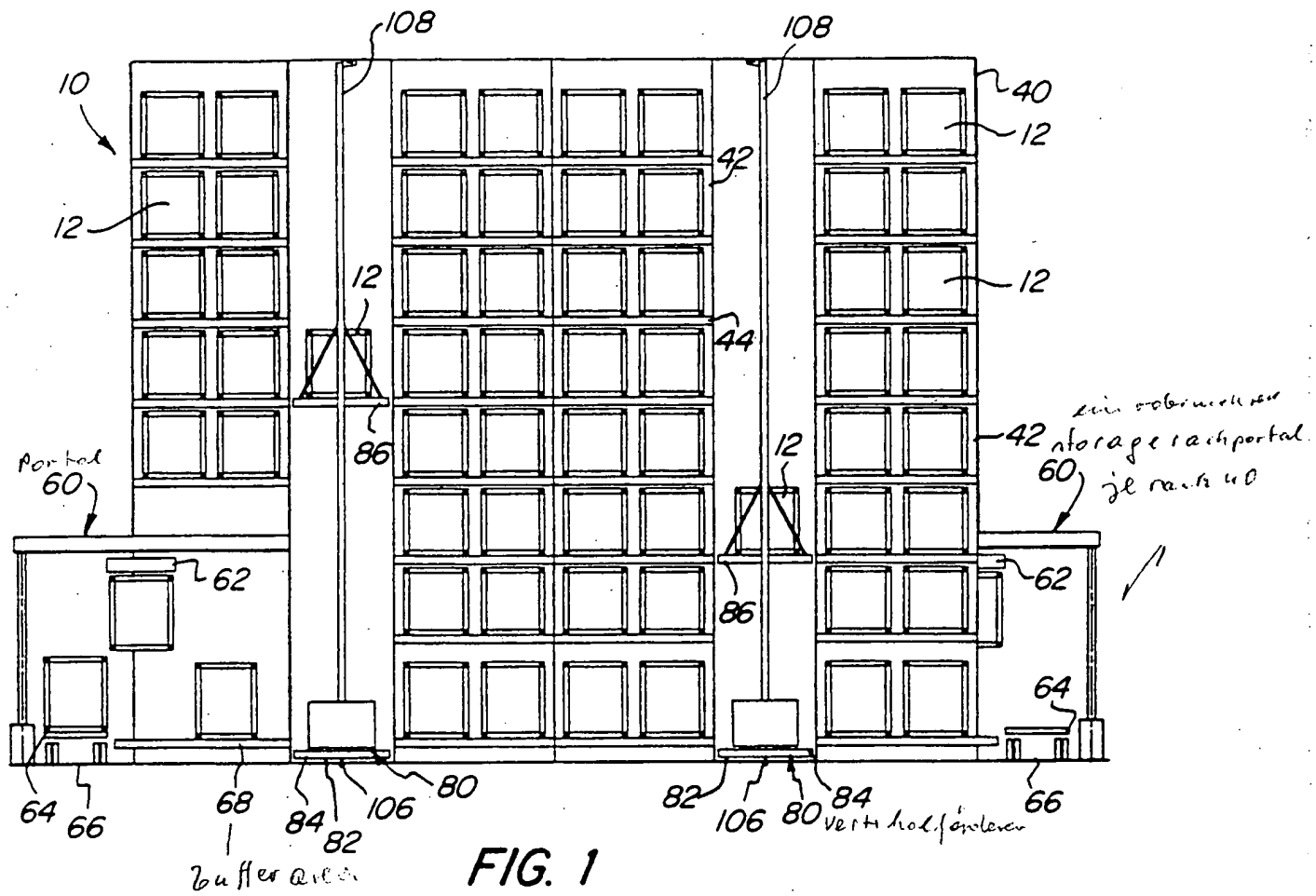
means for transmitting vertical and horizontal position inputs from said control unit to said positioning means.

9. A system in accordance with claim 8, further including a container tracking system comprising digital recording apparatus for recording position information received from said transmitting means and for recording information identifying a container located at a position identified by said position information, and means for retrieving recorded container identifying and position information.

10. A system in accordance with claim 1, wherein said system portal further comprises an overhead lifting

portal shuttle for lifting the container and conveying the container between a loading zone and a portal buffer area; said shuttle having access to and being movable to extend laterally into said portal buffer area to lift the container with said lifting devices and transport the containers to said cradle.

11. A system in accordance with claim 10, wherein said portal shuttle comprises a carriage, a hoist frame supported by said carriage, said hoist frame being movable relative to said carriage by positioning adjustment means, said carriage being laterally movable.



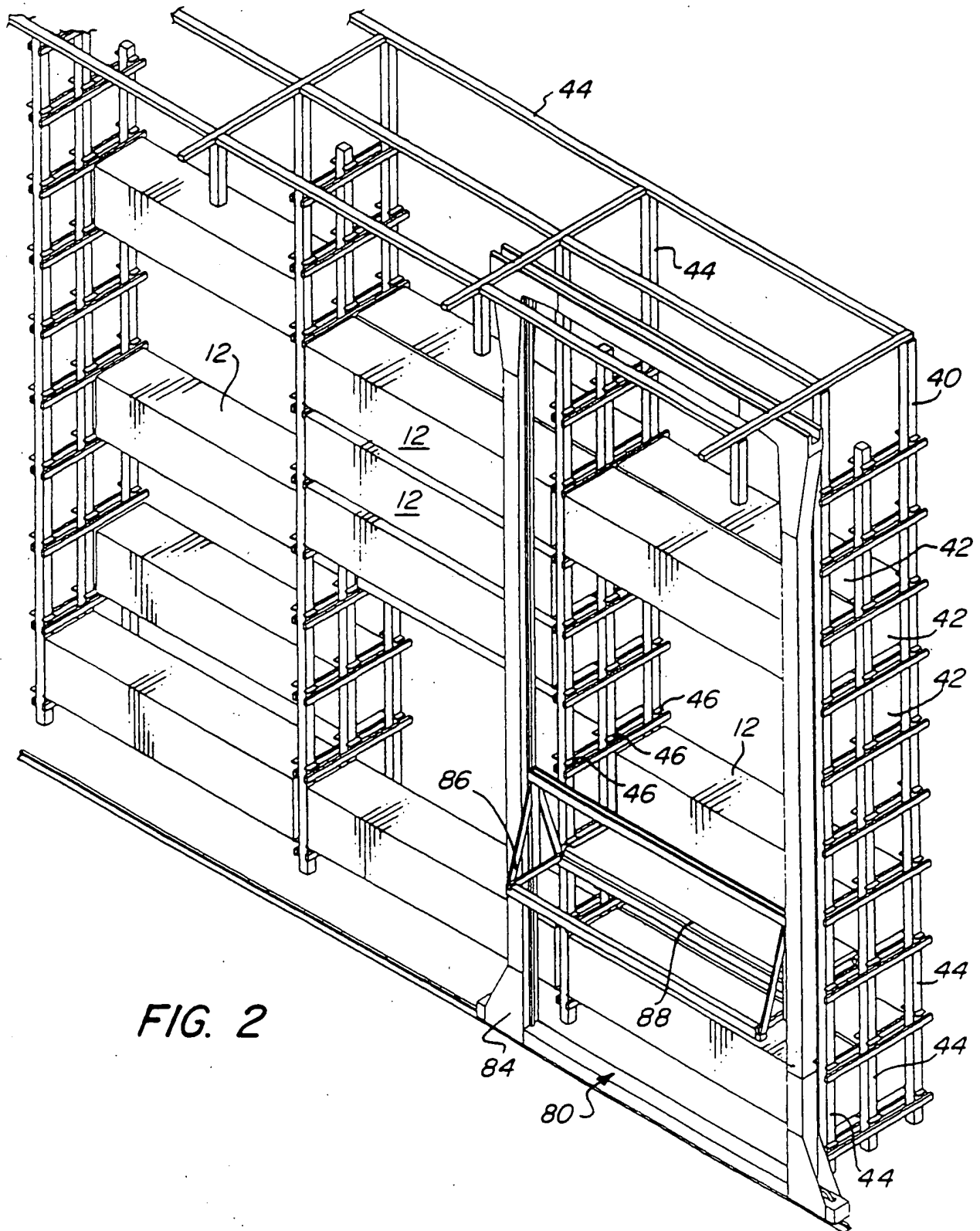


FIG. 3

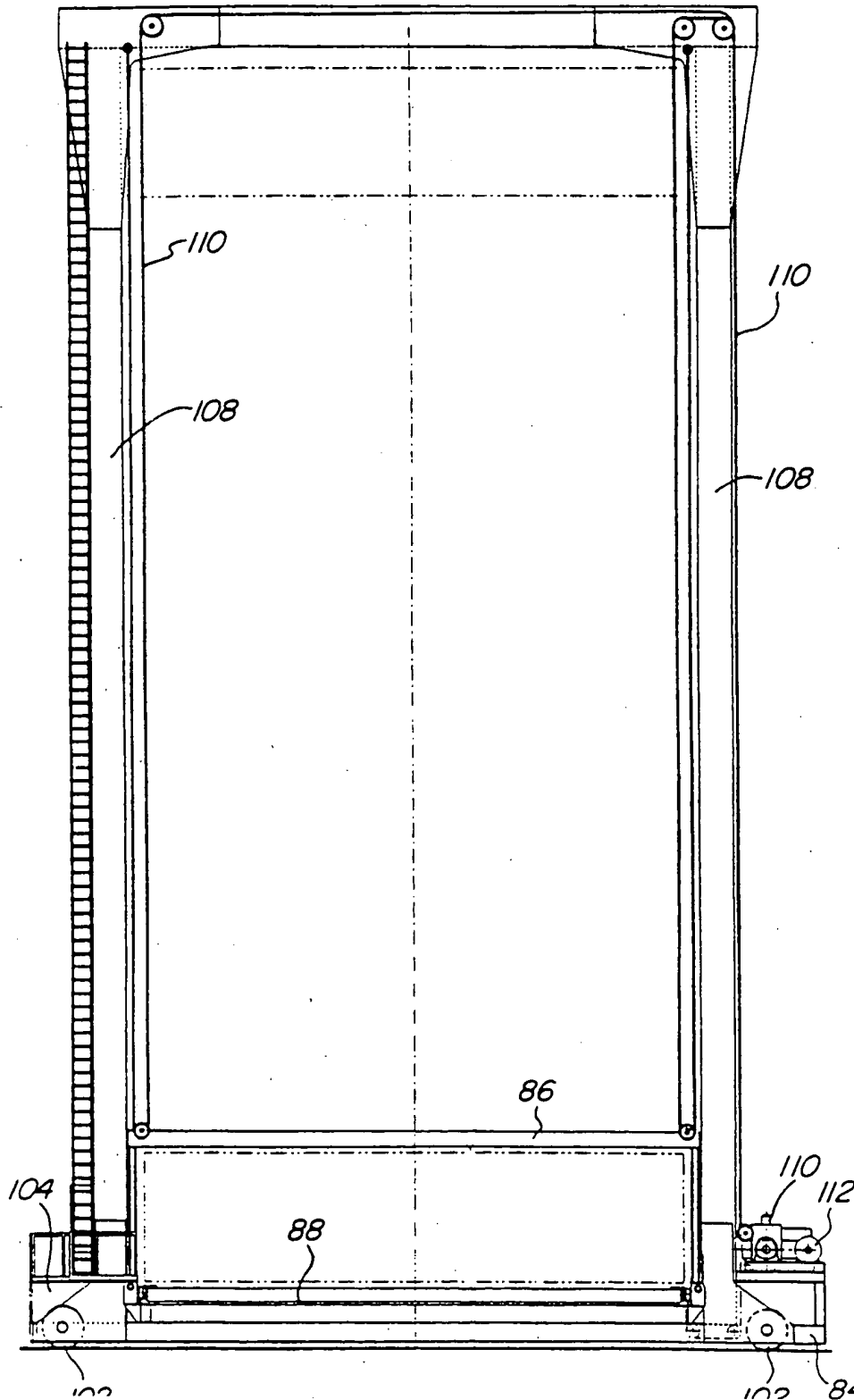
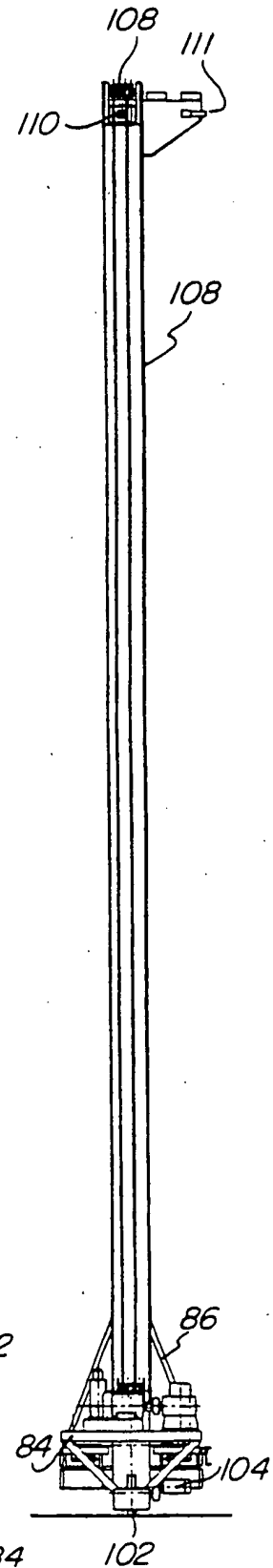


FIG. 4



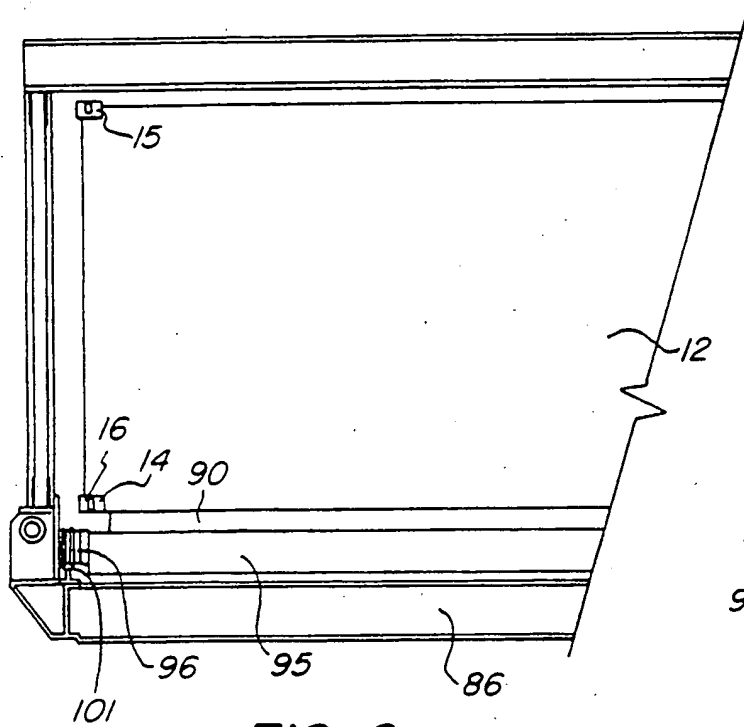


FIG. 6

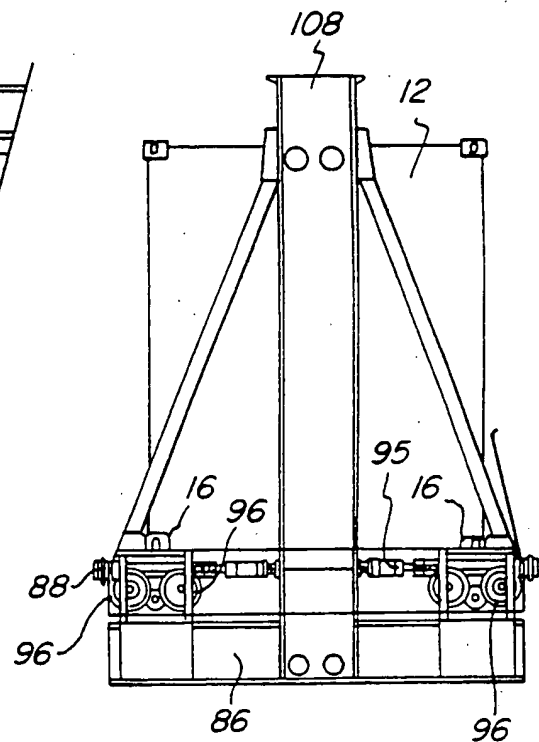


FIG. 7

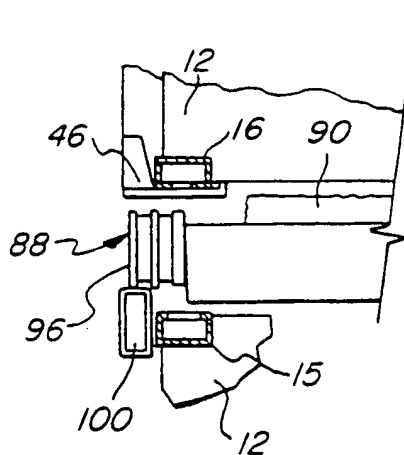


FIG. 8

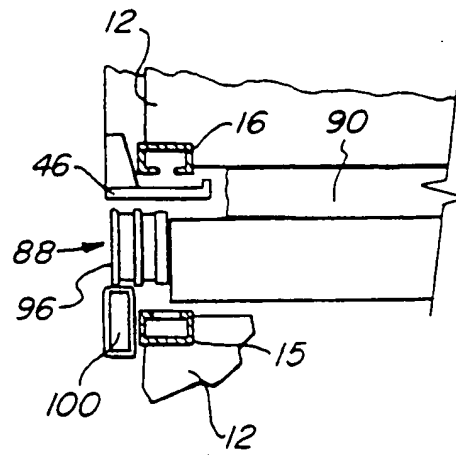


FIG. 9

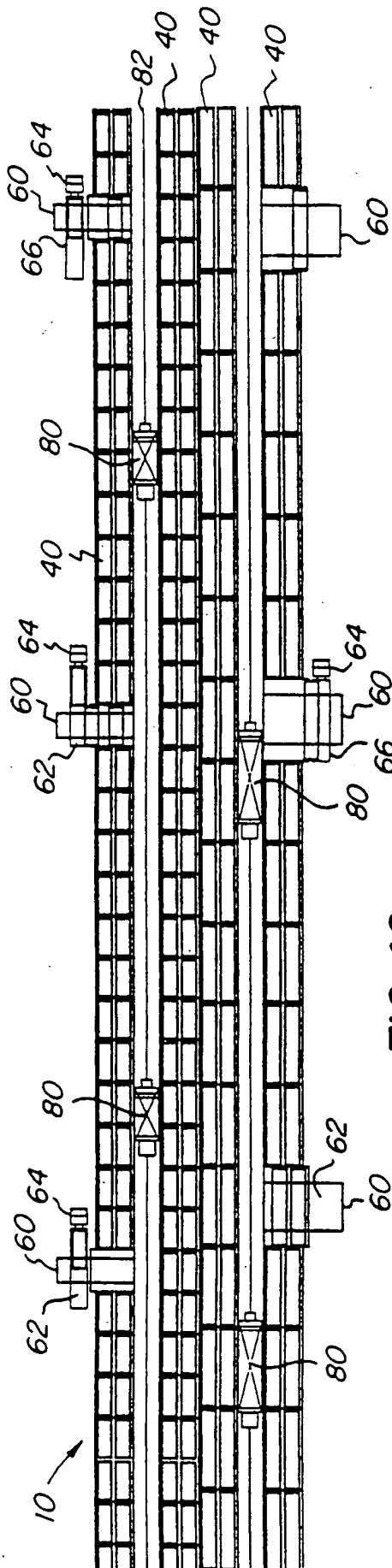


FIG. 10

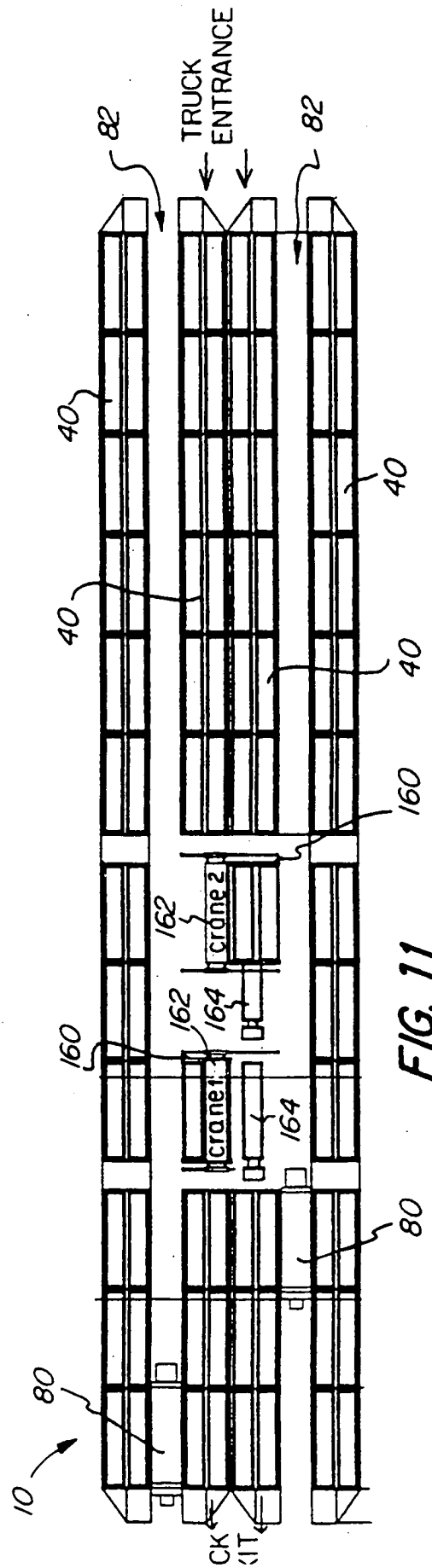


FIG. 11

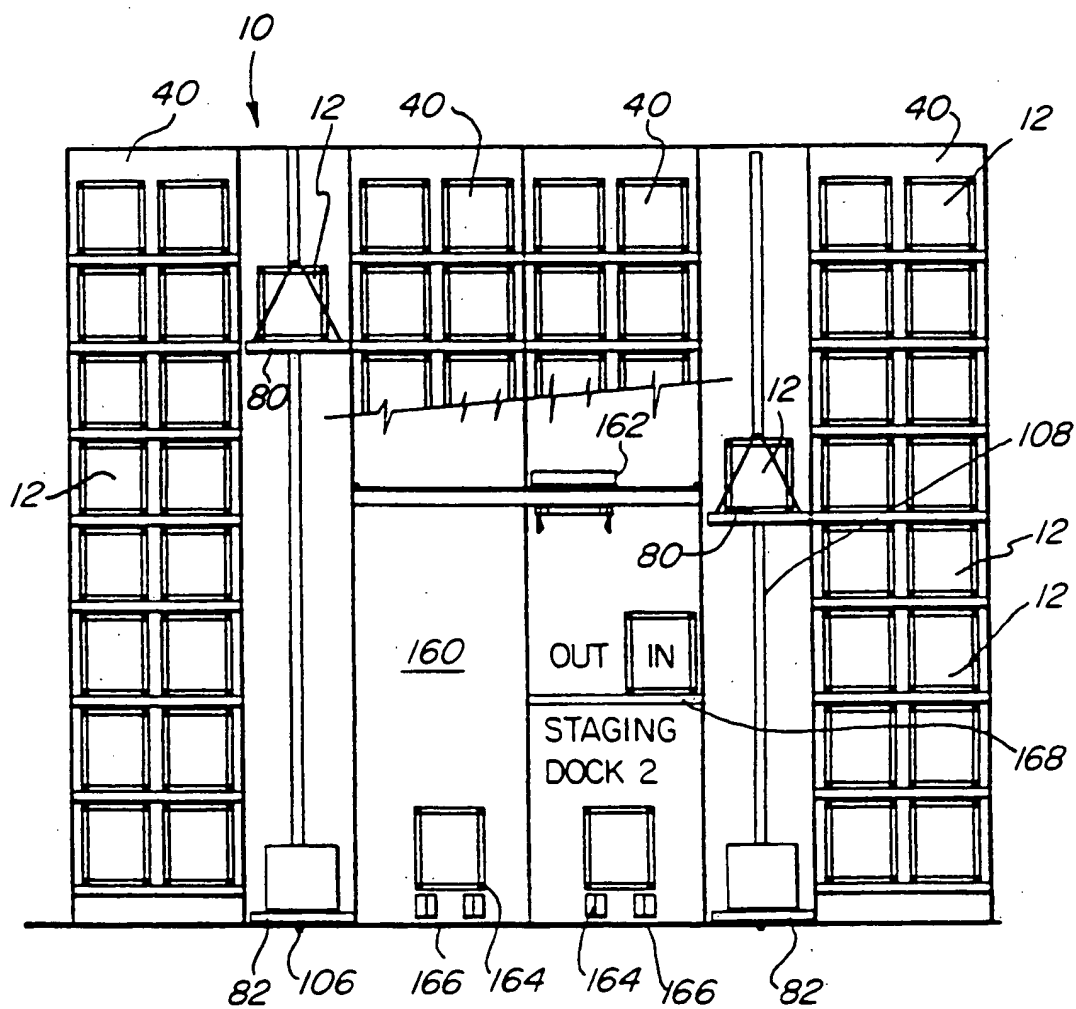


FIG. 12

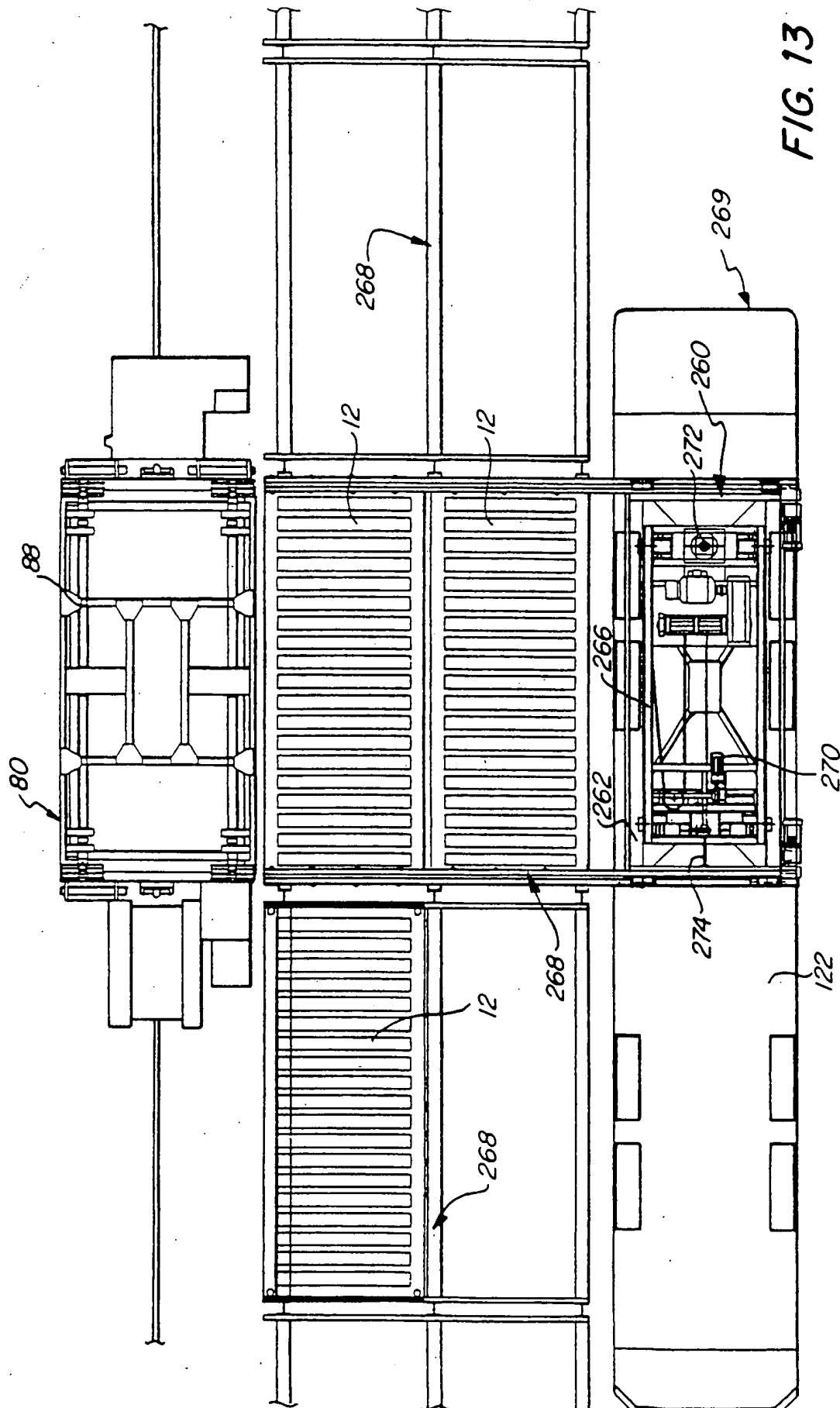
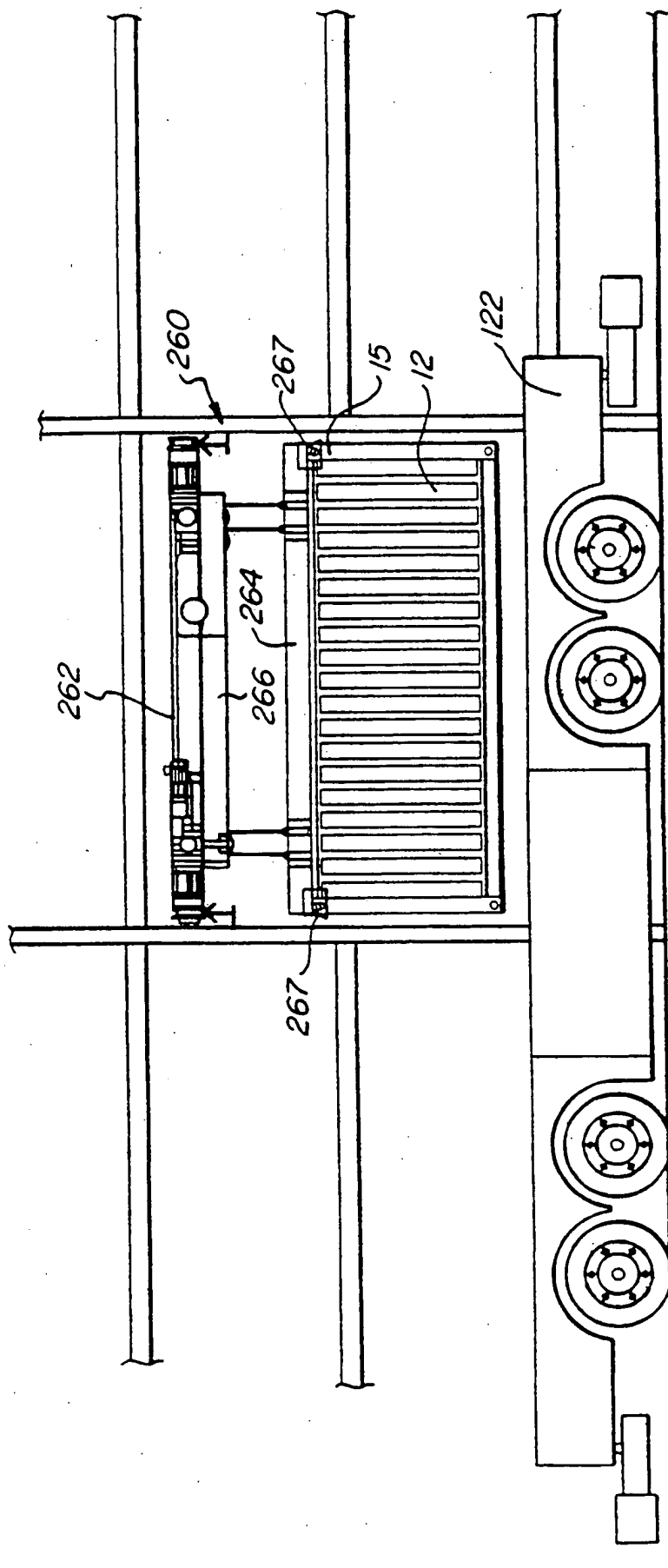


FIG. 14



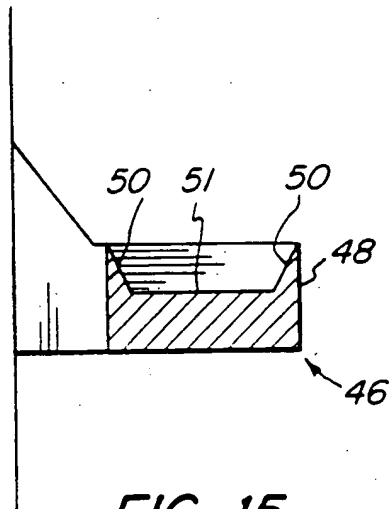


FIG. 15

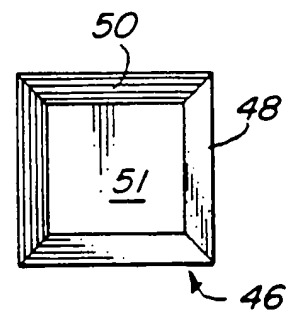


FIG. 16

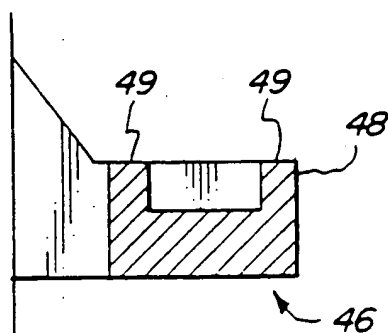


FIG. 17

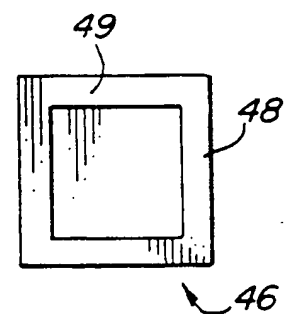
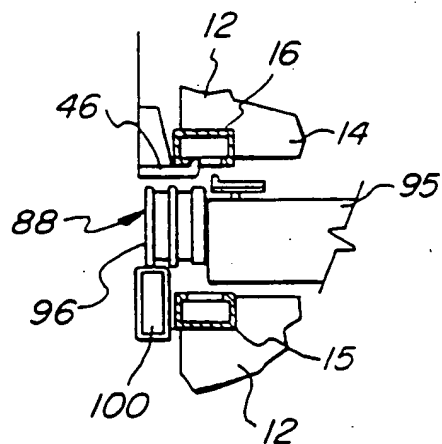
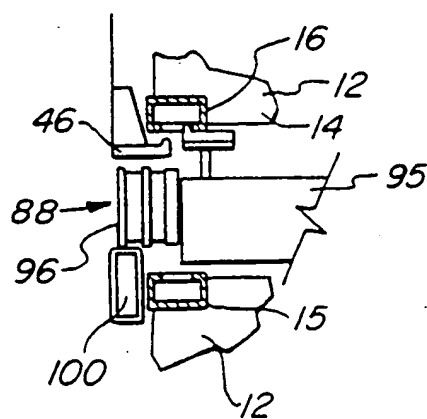


FIG. 18

**FIG. 19****FIG. 20**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US97/02424

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : B65G 1/04

US CL : 414/284

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|------------|--|-----------------------|
| A | US 1,261,504 A (Fitch) 02 April 1918 | None |
| A | US 3,432,046 A (Krusinski) 11 March 1969 | None |
| Y | US 3,836,020 A (Lassig) 17 September 1974 See Fig. 1 | 10,11 |
| A | US 3,978,995 A (Zollinger et al) 07 September 1976 | None |
| X | US 4,273,494 A (Swain et al) 16 June 1981 | 1,2,5,6 |
| ----- Y | See Entire Document | 3,4,7-11 |

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

| | | |
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| | * X | document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone |
| | * Y | document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |
| | * G | document member of the same patent family |

Date of the actual completion of the international search

14 APRIL 1997

Date of mailing of the international search report

14 MAY 1997

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/02424

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|------------|--|-----------------------|
| Y | US 4,286,911 A (Benjamin) 01 September 1981 See Fig. 27 | 8 |
| Y | US 4,427,331 A (Grebenstein et al) 24 January 1978 See Fig. 4 | 4 |
| A | US 4,459,078 A (Chiantella et al) 10 July 1984 | None |
| Y | US 4,460,214 A (Bruns) 03 February 1987 See Fig. 13 | 3 |
| Y | US 5,002,449 A (Kita et al) 26 March 1991 See entire document | 7-9 |
| Y | US 5,379,229 A (Parsons et al) 03 January 1995 See entire document | 7,9 |
| X | US 5,540,532 A (Carder et al) 30 July 1966 | 1,2,5-11 |
| ----- Y | See entire document | ----- 3,4 |

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US97/02424

B. FIELDS SEARCHED

Minimum documentation searched

Classification System: U.S.

414/284

414/390-392, 342, 399, 273, 277, 281, 267, 282, 284; 187/222;

211/191